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PROPELLERS

IRWIN WEISENBERG, M.E. III



P-38 Using Tri-bladed Propeller

Courtesy U. S. Steel News

In these times of sudden attacks from the air, the sound of roaring aircraft may bring fear or joy to those who hear it. Just exactly what causes a plane to produce vibrations that can be heard for miles around? Many people believe they are hearing the sound of the motor when the airplane passes over. This is not true. The fact is that the motor is but a minor contributor to the total effect created. The greatest noise producer in the whole structure is the propeller. The propeller is one of the loudest man-made sound producers in existence. It can be compared with signal devices such as fog horns, steam whistles, etc., quite favorably as far as volume of sound is concerned.

Several years ago, the National Advisory Committee for Aeronautics conducted a series of experiments to determine how much noise a propeller really makes. They constructed a test stand for the propeller using an electric motor for driving power instead of a gasoline engine. This eliminated any noise interference from explosions in the cylinders. It was found that instead of being just a single source of sound, the propeller produced four distinct classes of vibrations. The most important and principal sound, called the fundamental note, is created by the sudden compression and release of the air caused by the propeller's passing some object close to it, such as the cylinder heads or wing. This sound, the deep roar heard when a plane is passing, is greatest at 30 degrees behind the plane of rotation in the slipstream. This is one of the reasons why the maximum sound of the airplane is not heard until it is slightly past the observer. The note is not heard by the pilot, because it is at a minimum on the axis of rotation; for example, in single motored ships it passes through the cockpit.

Vortices or whirlpools of air are formed periodically on the trailing edge of each blade. The continual release of the partial vacuums formed in this way, constitutes another main source. When the plane is very close to or at a great distance from the observer, only the fundamental

note can be heard, but in between these distances the vortex note can be recognized by the swishing or tearing sound it produces.

The two other sounds, present only under certain conditions, are a constant frequency note believed to be caused by the constantly changing pressure about the width of the blade, and the slight vibrations set up by the propeller. (These are removed as much as possible in manufacture.)

In designing a propeller, the engineer constantly tries to increase efficiency, reliability, and safety. Usually each design is made with the idea that it will be used on a certain type engine, in a given plane, and at a certain speed. Sometimes the blades are considered as spirally moving wings, and the propeller is designed in much the same manner as a wing.

Early propellers, made of laminated wood, proved unsatisfactory because of their tendency toward warping, cracking, and splitting. To eliminate these defects and to provide for greater strength, the metal prop was developed. This may have either solid or hollow blades, usually made from the light magnesium and aluminum alloys. Wood, impregnated with phenol-formaldehyde resin, has also been tried as a propeller material.

The manufacture of metal airplane propellers is a precision process and therefore is not readily adaptable to mass production. However, the industry has developed numerous machines that greatly shorten the length of time of construction. The blades are first forged roughly to shape and tested for any minute flaws or cracks. Then, after a tapered hole, accurate to ten-thousandths of an inch, has been bored into the shank, the blade is placed lengthwise into a machine. This machine has a master cam that turns the prop at just the right interval for a moving tool to cut a twist into it. It takes only an hour to turn out a propeller with this equipment, although it takes 150

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hours to make a master cam. Another method of getting the same results is to use a blade twister. This machine, with a maximum torque of 530,000 pounds, will twist out a propeller directly from the forging, and thereby eliminate all machine work.

Why the difference in the number of blades used? Some planes use two-bladed props, others three, some four, etc. It might seem at first glance that the more blades the better propeller. However, there are several disadvantages to the multi-bladed propeller not found to such a great extent in the ordinary two-bladed type. The efficiency is definitely decreased, manufacturing processes as well as materials increase in cost, and shipping and packing becomes much more difficult.

The advantages of adding extra blades to the design are the greater increase in strength, smoother running, and the fact that the blades can be shortened, thereby eliminating large clearances or high landing gears. Thus, each new design of airplane that comes out of the drafting room requires a new design of propeller.

Although, basically, they will always remain the same, airplane propellers can still be improved upon in many ways. Some difficulty has been encountered in cooling the engine when the plane is on the ground or in a climb. The propeller is turning more slowly than when it is in level flight, and as a result, not enough air is forced back around the cylinder heads to cool them properly. Blowers or fins attached to the hub are not very satisfactory. It is believed that the air foil section close to the hub can be designed so that the desired flow of air can be obtained at slow as well as at level flight propeller speeds.

In the single seater fighter, the engine is so

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powerful that the reaction of the propeller torque makes the plane very difficult to handle when taking off. To counteract this effect double propellers have been experimented with. That is, two propellers mounted on the same shaft, one behind the other, but geared so that they will turn in opposite directions, are used. This arrangement not only eliminates the excessive torque, but also increases the propeller efficiency. This arrangement was used on the Italian *Macchi Castoldi* racing seaplane when it set a world speed record in 1934, of 440 miles per hour. The high takeoff speed needed for this plane caused a torque so great, when using an ordinary propeller, that the floats on one side would sink far down and keep the plane from leaving the water. This was eliminated very nicely by using two counter-propellers.

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